Fiscal Policy in a Model with Matching Frictions*

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Abstract

The endorsement of expansionary fiscal packages has often been based on the idea that large multipliers can contrast rising unemployment. Is that really the case? We explore those issues in a New Keynesian model in which unemployment arises because of matching frictions. We compare fiscal packages with different targets (pure demand stimuli versus subsidy to cost of hiring) and of government funding (lump sum taxation versus distortionary taxation). We find that in presence of demand stimuli fiscal multipliers are zero and even turn negative when financed with distortionary taxation. On the other side, in a model with a non-Walrasian labor market, policies aimed at reducing labor wedges, such as cost of hiring, are particularly effective in boosting employment and output.

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1 Introduction

The endorsement of expansionary fiscal packages has often been based on the idea that large multipliers can contrast rising unemployment. Following the 2007-2008 crisis, various national governments around the globe have passed expansionary fiscal packages arguing that, with nominal interest rates at the zero lower bound, only a strong fiscal stimuli could help in fighting the consequences of a recession associated with rising unemployment. Is that really the case? We explore those issues in a New Keynesian model in which unemployment arises because of matching frictions. We compare alternative fiscal packages both in terms of target for the fiscal stimulus and in terms of source of financing. We consider two forms of government spending: a traditional increase in aggregate demand; an increase in firms' hiring subsidy. Furthermore, we consider various forms of government financing, namely lump sum taxation versus distortionary taxation on labor.

Our results are as follows. Government expenditure in the form of aggregate demand stimuli produces low to nearly zero multipliers. Thus, in comparison to the standard New Keynesian model the expansionary effects of aggregate demand stimuli are much lower in a model with matching frictions. When distortionary taxation is used, multipliers become even negative. The reason being as follows. Consider a model with non-walrasian labor markets. In order to accommodate the increase in aggregate demand firms would have to post more vacancies. For this to become an equilibrium outcome, the continuation value of a filled vacancy needs to be higher than its steady state value, which in turn requires an increase in the stochastic discount factor and in current consumption. However due to the crowding out effect current consumption falls, therefore implying a fall in current vacancy posting. The fall in vacancy posting brings about a fall in employment and output. Our results show, on the other side, that when the fiscal stimulus takes the form of subsidy to cost of posting vacancies, fiscal multipliers turn positive and become significantly large. A reduction in the cost of posting vacancies boosts job creation which in turn induces an increase in employment and output. This effect is particularly powerful when the model

features inefficient unemployment fluctuations, which occur to the extent that the Hosios condition does not hold. In this case indeed the fall in the cost of posting vacancies also reduces the distortions present in the economy, therefore moving the long run level of output toward the potential one.

To check robustness of our results we consider fiscal stimuli in combination with an interest rate peg. This case is of interest since over the last year countries like the U.S. were close to the zero lower bound on interest rate and have thus adopted a policy mix in which the monetary authority kept the interest rate fixed at low levels while the fiscal authority had passed large fiscal packages. We find that a temporary interest rate peg (the monetary authority keeps the nominal interest rate constant for one year) coupled with fiscal stimuli increases the multiplier both, in the standard New Keynesian model and in the model with search and matching frictions. This result echoes the ones reported in Christiano, Eichenbaum and Rebelo (4). Finally, our results go through even when assuming that the economy starts from a recession scenario, when we change the degree of price stickiness and when we add wage rigidity[1].

Our measure of the fiscal multiplier should be compared to those found in recent literature. Following Romer and Bernstein (18) which, by evaluating the fiscal stimulus package approved in the United States from the Obama administration, have found fiscal multipliers significantly larger than one, several other authors have revised such estimates offering less favorable scenarios (see Cogan, Cwik, Taylor and Wieland (5), Cwik and Wieland (7), Uhlig (21) among others). Christiano, Eichenbaum and Rebelo (4) argue that fiscal multipliers might be larger than one when the interest rate is at the zero lower bound. All of those studies have considered simple and stylized RBC or New Keynesian models in which unemployment is absent and the labor market is frictionless. the only exception is Faia, Lechthaler and Merkl (9), who analyze fiscal multipliers in an open economy model with labor turnover costs.

[1]The latter is considered in order to obtain larger fluctuations in unemployment consistently with the implications of the Shimer puzzle.

With respect to the literature, our contribution is twofold. First, we show that non-Walrasian labor markets are a crucial dimension in evaluating fiscal multipliers, as the actual stimulus of a demand shock might be lower than expected. Second, we show that when government spending is used to finance labor market policies like hiring subsidies, the fiscal multipliers may be well above one.

The structure of the paper is as follows. Section 2 presents the model economy and the fiscal policy packages considered. Section 3 provides the intuition for the main mechanism at work for the real business cycle version of the model. Section 4 shows simulation results on the fiscal multipliers for the general version of the model, providing also robustness checks. Section 5 concludes.

2 A New Keynesian Model with Matching Frictions

Our model economy borrows from Krause and Lubik (13). There is a continuum of agents whose total measure is normalized to one. The economy is populated by households who consume different varieties of goods, save and work. Households save in both non-state contingent securities and in an insurance fund that allows them to smooth income fluctuations associated with periods of unemployment. Each agent can indeed be either employed or unemployed. In the first case he receives a wage that is determined according to a Nash bargaining, in the second case he receives an unemployment benefit. The labor market is characterized by matching frictions and exogenous job separation. The production sector acts as a monopolistic competitive sector which produces a differentiated good using labor as input and faces adjustment costs a' la Rotemberg (19).

2.1 Households

Let $c_t \equiv \left[\int_0^1 c_t(i)^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}}$ be a Dixit-Stiglitz aggregator of different varieties of goods. The optimal allocation of expenditure on each variety is given by $c_t(i) = \left(\frac{p_t(i)}{p_t}\right)^{-\varepsilon} c_t$, where $p_t \equiv \left[\int_0^1 p_t(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}$ is the price index. There is continuum of agents who maximize the

expected lifetime utility[2].

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \right\} \tag{1}$$

Households supply labor hours inelastically h (which is normalized to 1). Unemployed households members receive an unemployment benefit, b. Total real labor income is given by $w_t n_t$. The contract signed between the worker and the firm specifies the wage and is obtained through a Nash bargaining process. In order to finance consumption at time t each agent also invests in non-state contingent nominal government bonds B_t which pay a gross nominal interest rate $(1 + r_t^n)$ one period later. As in Andolfatto (1) and Merz (15) it is assumed that workers can insure themselves against earning uncertainty and unemployment. For this reason the wage earnings have to be interpreted as net of insurance costs. Finally agents receive profits from the monopolistic sector which they own, Θ_t. Agents are subject to the following tax system: τ_t^n represents tax on wages, τ_t^c represents tax on consumption and τ_t represents lump sum taxation. The sequence of real budget constraints reads as follows:

$$(1+\tau_t^c)c_t + \frac{B_t}{p_t} \leq (1-\tau_t^n)w_t n_t + b(1-n_t) + \frac{\Theta_t}{p_t} - \tau_t + (1+r_{t-1}^n)\frac{B_{t-1}}{p_t} \tag{2}$$

Households choose the set of processes $\{c_t, B_t\}_{t=0}^{\infty}$ taking as given the set of processes $\{p_t$, w_t, r_t^n, τ_t^c, τ_t^n, τ_t, $\Theta_t\}_{t=0}^{\infty}$ and the initial wealth B_0, so as to maximize (1) subject to (2). Let's define λ_t as the Lagrange multiplier on constraint (2). The following optimality conditions must hold:

$$\lambda_t = \frac{c_t^{-\sigma}}{1+\tau_t^c} \tag{3}$$

$$\frac{c_t^{-\sigma}}{1+\tau_t^c} = \beta(1+r_t^n)E_t \left\{ \frac{c_{t+1}^{-\sigma}}{1+\tau_{t+1}^c} \frac{p_t}{p_{t+1}} \right\} \tag{4}$$

Equation (3) is the marginal utility of consumption and equation (4) is the Euler condition with respect to bonds. Optimality requires that No-Ponzi condition on wealth is also satisfied.

[2]Let $s^t = \{s_0, ...s_t\}$ denote the history of events up to date t, where s_t denotes the event realization at date t. The date 0 probability of observing history s^t is given by ρ_t. The initial state s^0 is given so that $\rho_0 = 1$. Henceforth, and for the sake of simplifying the notation, let's define the operator $E_t\{.\} \equiv \sum_{s_{t+1}} \rho(s^{t+1}|s^t)$ as the mathematical expectations over all possible states of nature conditional on history s^t.

2.2 The Production Sector

Firms in the production sector sell their output in a monopolistic competitive market and meet workers on a matching market. The labor relations are determined according to a standard Mortensen and Pissarides (16) framework. Workers must be hired from the unemployment pool and searching for a worker involves a fixed cost. Workers wages are determined through a Nash decentralized bargaining process which takes place on an individual basis.

2.2.1 Search and Matching in the Labor Market

The search for a worker involves a fixed cost κ and the probability of finding a worker depends on a constant return to scale matching technology which converts unemployed workers u and vacancies v into matches, m:

$$m(u_t, v_t) = m u_t^{\xi} v_t^{1-\xi} \tag{5}$$

where $v_t = \int_0^1 v_t(i)di$. Defining labor market tightness as $\theta_t \equiv \frac{v_t}{u_t}$, the firm meets unemployed workers at rate $q(\theta_t) = \frac{m(u_t,v_t)}{v_t} = m\theta_t^{-\xi}$, while the unemployed workers meet vacancies at rate $\theta_t q(\theta_t) = m\theta_t^{1-\xi}$. If the search process is successful, the firm in the monopolistic good sector operates the following technology:

$$y_t(i) = z_t n_t(i) \tag{6}$$

where z_t is the aggregate productivity shock which follows a first order autoregressive process, $\log z_t = \rho_z \log z_{t-1} + \varepsilon_{z,t}$, and $n_t(i)$ is the number of workers hired by firm i. Matches are destroyed at an exogenous rate[3] ρ. Labor force is normalized to unity. The number of employed people at time t in each firm i is given by the number of employed people at time $t-1$ plus the flow of new matches concluded in period t who did not discontinue the match:

$$n_t(i) = (1-\rho)n_{t-1}(i) + v_t(i)q(\theta_t) \tag{7}$$

[3]The alternative assumption of endogenous job destruction would induce, consistently with empirical observations, additional persistence as shown in den Haan, Ramsey and Watson (8). However due to the normative focus of this paper we choose the more simple assumption of exogenous job separation.

Hiring in this model is instantaneous. At the beginning of period t firms observe the realization of the stochastic variables and post vacancies accordingly. Those vacancies are matched with the pool of searching workers which is given by the workers not employed at the end of period $t-1$, $u_t = 1-(1-\rho)n_{t-1}$.

2.2.2 Monopolistic Firms

There is continuum of firms which hire a continuum of workers. Firms in the monopolistic sector use labor to produce different varieties of consumption good and face a quadratic cost of adjusting prices and costs of posting vacancies which are linear in the number of vacancies. Due to the constant return to scale of vacancy posting technology, firms can take wages as given when choosing prices and employment. Wages are determined through the bargaining problem analyzed in the next section. Here we develop the dynamic optimization decision of firms choosing prices, $p_t(i)$, number of employees, $n_t(i)$, and number of vacancies, $v_t(i)$, to maximize the discounted value of future profits and taking as given the wage schedule. The representative firm chooses $\{p_t(i), n_t(i), v_t(i)\}$ to solve the following maximization problem (in real terms):

$$Max\ E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left\{ \frac{p_t(i)}{p_t} y_t(i) - w_t(i)n_t(i) - (1-\tau_t^k)\kappa v_t(i) - \frac{\psi}{2}\left(\frac{p_t(i)}{p_{t-1}(i)} - 1\right)^2 y_t \right\} \tag{8}$$

subject to

$$y_t(i) = \left(\frac{p_t(i)}{p_t}\right)^{-\epsilon} y_t = z_t n_t(i) \tag{9}$$

$$n_t(i) = (1-\rho)n_{t-1}(i) + v_t(i)q(\theta_t) \tag{10}$$

where y_t is the aggregate demand which is given by consumption, c_t, plus government expenditure, g_t. $\frac{\psi}{2}\left(\frac{p_t(i)}{p_{t-1}(i)} - 1\right)^2 y_t$ represents the cost of adjusting prices, ψ can be thought as the sluggishness in the price adjustment process, κ as the cost of posting vacancies, τ_t^k is a subsidy to the cost of posting vacancies, and $w_t(i)$ denotes the fact that the bargained wage might depend on time varying factors. Let's define mc_t, the Lagrange multiplier on constraint (9), as the marginal cost of firms and μ_t, the Lagrange multiplier on constraint

(10), as the marginal value of one worker. Since all firms will choose in equilibrium the same price and allocation we can now assume symmetry and drop the index i. First order conditions for the above problem read as follows:

- n_t :

$$\mu_t = mc_t z_t - w_t + \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t}(1-\rho)\mu_{t+1} \right\} \tag{11}$$

- v_t :

$$\frac{\kappa(1-\tau_t^k)}{q(\theta_t)} = \mu_t \tag{12}$$

- p_t :

$$\psi(\pi_t - 1)\pi_t - \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t}\psi(\pi_{t+1}-1)\pi_{t+1}\frac{y_{t+1}}{y_t} \right\} = 1 - \varepsilon(1 - mc_t) \tag{13}$$

By merging (11) and (12) we obtain the job creation condition:

$$\frac{\kappa(1-\tau_t^k)}{q(\theta_t)} = mc_t z_t - w_t + \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t}(1-\rho)\frac{\kappa(1-\tau_{t+1}^k)}{q(\theta_{t+1})} \right\} \tag{14}$$

Rearranging equation (14) we obtain the following expression for the marginal cost:

$$mc_t = \frac{w_t}{z_t} + \frac{\frac{\kappa(1-\tau_t^k)}{q(\theta_t)} - \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t}(1-\rho)\frac{\kappa(1-\tau_{t+1}^k)}{q(\theta_{t+1})} \right\}}{z_t} \tag{15}$$

As already noticed in Krause and Lubik (13) in a matching model the marginal cost of firms is given by the marginal productivity of each single employee, $\frac{w_t}{z_t}$, as it is in a standard Walrasian model but it also contains an extra component, which depends on the future value of a match. Posting vacancy is costly hence a successful match today is valuable also since it reduces future search costs. In this context wages maintain their allocative role only for future matches.[4]

[4]See Goodfriend and King (10).

2.2.3 Bellman Equations, Wage Setting and Nash Bargaining

The wage schedule is obtained through the solution to an individual Nash bargaining process. To solve for it we need first to derive the marginal values of a match for both, firms and workers. Those values will indeed enter the sharing rule of the bargaining process. Let's denote by V_t^J the marginal discounted value of a vacancy for a firm. From equation (11) and noticing that $V_t^J = \mu_t$ we obtain:

$$V_t^J = mc_t z_t - w_t + \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t}(1-\rho)V_{t+1}^J \right\} \tag{16}$$

The marginal value of a vacancy depends on real revenues minus the real wage plus the discounted continuation value. With probability $(1-\rho)$ the job remains filled and earns the expected value and with probability, ρ, the job is destroyed and has zero value. In equilibrium the marginal discounted value of a vacancy should equalize the expected cost of posting vacancies. For each worker, the values of being employed and unemployed are given by V_t^E and V_t^U:

$$V_t^E = (1-\tau_t^n)w_t + \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left[(1-\rho)V_{t+1}^E + \rho V_{t+1}^U \right] \right\} \tag{17}$$

$$V_t^U = b + \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left[\theta_{t+1} q(\theta_{t+1})(1-\rho)V_{t+1}^E + (1-\theta_{t+1}q(\theta_{t+1})(1-\rho))V_{t+1}^U \right] \right\} \tag{18}$$

where b denotes real unemployment benefits. Workers and firms are engaged in a Nash bargaining process to determine wages. The optimal sharing rule of the standard Nash bargaining is given by:

$$(V_t^E - V_t^U) = \frac{\varsigma}{1-\varsigma} V_t^J \tag{19}$$

After substituting the previously defined value functions it is possible to derive the following wage schedule:

$$w_t = \frac{1}{1-\tau_t^n(1-\varsigma)} \left(\varsigma mc_t z_t + \varsigma(1-\rho)\beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \kappa(1-\tau_{t+1}^k)\theta_{t+1} \right\} + (1-\varsigma)b \right) \tag{20}$$

2.3 Equilibrium Conditions

Aggregate output is obtained by aggregating production of individual firms and by subtracting the resources wasted into the search activity and the cost of adjusting prices:

$$y_t = n_t z_t - \kappa v_t - \frac{\psi}{2}\left(\frac{p_t}{p_{t-1}} - 1\right)^2 y_t \tag{21}$$

2.4 Monetary Policy

Monetary policy is conducted by means of an interest rate reaction function of this form:

$$\begin{aligned}\ln\left(\frac{1+r_t^n}{1+r^n}\right) &= (1-\phi_r)\left(\phi_\pi \ln\left(\frac{\pi_t}{\pi}\right) + \phi_y \ln\left(\frac{y_t}{y}\right)\right) \\ &+ \phi_r \ln\left(\frac{1+r_{t-1}^n}{1+r^n}\right)\end{aligned} \tag{22}$$

2.5 Fiscal policy regimes

The government faces the following budget constraint:

$$g_t + b(1-n_t) + (1+r_{t-1}^n)\frac{B_{t-1}}{p_t} + \tau_t^k \kappa v_t = \tau_t^c c_t + \tau_t^n w_t n_t + \frac{B_t}{p_t} + \tau_t \tag{23}$$

Since government expenditure is financed partly with taxes and partly with government bonds we need some rule to pin down the evolution of government bonds. First we assume that $\tau_t = \tau$, $\tau_t^c = \tau^c$, and that government expenditure follows an exogenous process. Furthermore, following Uhlig (21) we assume that a fraction ϕ of expenditure is financed through tax and the remaining part through government bonds:

$$\tau_t^n w_t n_t = \phi\left(g_t + b(1-n_t) + \tau_t^k \kappa v_t - \tau_t + (1+r_{t-1}^n)\frac{B_{t-1}}{p_t} - \tau_t^c c_t\right) \tag{24}$$

We consider two possible targets for government expenditure: aggregate demand and subsidy to cost of posting vacancies. They are both modeled through temporary shocks. Government expenditure in the form of demand stimuli takes the following form:

$$\frac{g_t}{g} = \left(\frac{g_{t-1}}{g}\right)^{\rho_g} + \varepsilon_t^g \tag{25}$$

where ε_t^g is a surprise increase. A hiring subsidy takes instead the following form:

$$\frac{\tau_t^k}{\tau^k} = \left(\frac{\tau_{t-1}^k}{\tau^k}\right)^{\rho_{\tau^k}} + \varepsilon_t^{\tau^k} \tag{26}$$

where $\varepsilon_t^{\tau^k}$ is a surprise increase.

2.6 Calibration

Preferences. Time is measured in quarters. The discount factor β is set equal to 0.99, so that the annual interest rate is equal to 4 percent. The parameter on consumption in the utility function, σ, is set equal to 2.

Production. Following Basu and Fernald (2), the value added mark-up of prices over marginal cost is set to 0.2. This generates a value for the price elasticity of demand ε of 6. The cost of adjusting prices, ψ, is set to 30 so as to generate a slope of the log-linear Phillips curve consistent with empirical and theoretical studies (average price duration of 3 quarters).

Labor market frictions parameters. The matching technology is a homogenous of degree one function and is characterized by the parameter ξ. Consistently with estimates by Blanchard and Diamond (3) this parameter is set to 0.4. The exogenous separation probability, ρ, is set to 0.07 consistently with estimates from Hall (11); this value is also compatible with those used in the literature which range from 0.07 (Merz (15)) to 0.15 (Andolfatto (1)). The steady state unemployment rate is set equal to 12% which is the value used by Krause and Lubik (13). With those two values we can compute the steady state for employment. We set the steady state firm matching rate, $q(\theta)$, to 0.7 which is the value used by den Haan, Ramey and Watson (8). With those values and using the fact that steady state number of matches is given by $\frac{\rho}{1-\rho}(1-u)$, it is possible to determine the number of vacancies, the vacancy/unemployment ratio as well as the scale parameter, m. The value for b is set so as to generate a steady state ratio $\frac{b}{w}$ of 0.5 which corresponds to the average value observed for industrialized countries (see Nickell and Nunziata (17)). The bargaining power of workers, ς, is set to 0.5 as in most papers in the literature, while the value for the

cost of posting vacancies is obtained from the steady state version of labor market tightness evolution. Note that we set $\varsigma > \xi$ implying that the Hosios (12) condition for efficiency is not satisfied. The rationale for this choice is that we want to analyze a fiscal package in form of a hiring subsidy which is only a reasonable instrument when not imposing an efficient unemployment rate.

Monetary policy parameters. The coefficient on inflation, ϕ_p, is set to 1.5, the coefficient on output, ϕ_y, is set 0.5/4. Finally the parameter ϕ_r is set equal to zero in the baseline calibration.

Fiscal policy parameters. The constant fraction of public spending, g, financed by current taxes is calibrated so as to match $g/y = 0.15$. Steady state taxes are set to $\tau^c = 0.05$ and $\tau^n = 0.28$ which are values calculated for the US by Trabandt and Uhlig (20). The steady state level of the hiring subsidy is set to $\tau^k = 0.01$. Given those values, the steady state value of the government debt will depend on ϕ. As a baseline we set $\phi = 0.275$ implying $\frac{B}{y} = 0.6$, but we also consider the following limiting cases: 0 and 1.

Shocks. The autocorrelation of government spending, ρ_g, and the hiring subsidy, ρ_{τ^k}, are calibrated to 0.9.

3 Special Case: Dynamics under Flexible Prices

Before analyzing the fiscal multipliers in the general New Keynesian model, it is useful to understand how the presence of matching frictions alters the transmission of a government spending shock in a real business cycle framework. When studying the model with Walrasian labor market, we consider the following utility function: $U_t = \frac{c_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi}$ i.e. we substitute employment n_t with hours N_t. In what follows we assume a constant technology z, so that movements in the variables are driven only by changes in fiscal policy.

3.1 RBC model with Walrasian Labor Market

The model is characterized by the following labor supply equation[5]:

$$\frac{\varepsilon - 1}{\varepsilon} z(1 - \tau_t^n) = N_t^{\varphi} c_t^{\sigma} \tag{27}$$

Suppose there in an increase in government spending financed by lump-sum taxes, so that τ_t^n is constant. Then the left hand side of this equation remains constant. This implies that in equilibrium the increase in N, as required by an increase in production, is accompanied by a decrease in consumption. Hence an increase in government spending tends to crowd out private consumption. The more so the higher the parameter φ. Thus, in this model the fiscal multiplier is always below one and decreases when the elasticity of labor supply, φ, increases. If the spending is financed, fully or in part, with distortionary labor taxes, the left hand side decreases when τ_t^n increases. Thus, for a given level of government spending and for given elasticity of labor supply, φ, the drop in consumption is larger the higher the increase in taxes, τ_t^n. Hence, financing government spending with distortionary taxation reduces the fiscal multiplier even more than the use of lump sum taxation. The next step we undertake is to analyze the impact of matching frictions on the fiscal multiplier.

3.2 RBC model with Matching Frictions

As we will prove in this section, in presence of matching frictions the fiscal multipliers turn even negative, the reason being that an increase in government spending induces not only a crowding out of private consumption but also a fall in employment.

To simplify the analysis, we assume that workers have zero bargaining power ($\varsigma = 0$). Under flexible prices the marginal cost stays constant, $mc_t = \frac{\varepsilon-1}{\varepsilon}$. Using the latter relation and combining the wage equation (20) with the job creation condition (14), we obtain:

[5]Recall that under flexible prices the optimal pricing rule implies $mc_t = \frac{\varepsilon-1}{\varepsilon}$. With linear production technology we have $mc_t = \frac{w_t}{z}$ and from the household problem the (net) real wage has to equate the marginal rate of substitution between consumption and leisure, $(1 - \tau_t^n)w_t = N_t^{\varphi} c_t^{\sigma}$.

$$\frac{\varepsilon-1}{\varepsilon}z-\frac{b}{1-\tau_t^n}=\frac{\kappa(1-\tau_k)}{m}\theta_t^{\xi}-(1-\rho)\beta\frac{\kappa(1-\tau_k)}{m}E_t\left\{\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}\theta_{t+1}^{\xi}\right\} \tag{28}$$

Under lump-sum taxation, and maintaining τ_t^n constant, the left hand side of (28) stays constant. In order to accommodate the increase in g, firms will have to post more vacancies at time t. Therefore, given that u_t adjusts one period later, labor market tightness θ_t will increase. As we consider a temporary government spending shock, we expect firms to post less vacancies in future periods, hence we expect $\theta_{t+1} < \theta_t$. Thus, for firms to post more vacancies today, we need the continuation value of a filled vacancy, $E_t\left\{\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}\theta_{t+1}^{\xi}\right\}$, to be higher than its steady state value. This would require an increase in the stochastic discount factor, $\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}$, which in turn requires an increase in current consumption. However, due to the crowding out effect of government spending, current consumption will actually decrease, thus inducing a fall in vacancy posting below steady state value. Overall, the fall in vacancies induces a fall in employment which brings about negative fiscal multipliers.

If labor taxes are used to finance the increase in government spending, the left hand side decreases, thus requiring an even bigger reduction in vacancy posting. Therefore, in such a framework an increase in government spending will actually induce a negative multiplier since firms will reduce vacancy posting below the steady state value.

The presence of sticky prices will induce higher multipliers in both models. However, we can already expect the multipliers of a government spending shock to be lower in a model with matching frictions.

4 Fiscal multipliers

For each fiscal intervention considered we compute short run and long run multipliers both in terms of GDP, $z_t n_t$, and in terms of aggregate demand, y_t. Short-run multipliers are calculated as output effects during the impact period divided by costs during the impact period. Long-run multipliers are the discounted output effects divided by the discounted costs. All graphs are normalized such that they represent a one percent spending package

during the implementation period. Results are summarized in Tables 1 and 2. Furthermore, we follow Uhlig (21) and compute dynamic multipliers whose value at time t is equal to the sum of discounted GDP (or aggregate demand) changes until time t divided by the sum of discounted cost changes until time t.

4.1 Demand stimulus

We start by considering a temporary one percent increase in government spending which is either financed by lump sum taxes or by distortionary labor taxes. As baseline value we set $\phi = 0.275$. We also consider two alternative values for this parameter: $\phi = 0$ (equivalent to lump sum taxation) and $\phi = 1$. To highlight the role of search and matching frictions we compare the fiscal multipliers in the New Keynesian model with search and matching with the ones in the standard New Keynesian model.[6] Recall that in the standard New Keynesian model, equilibrium unemployment is absent, hence fiscal stimuli occur solely through increases in aggregate demand.

Figure 1 shows the fiscal multipliers in the New Keynesian model with search and matching. The exact numbers are also summarized in Tables 1 and 2 for both, short run and long run multipliers. The multipliers are very small (nearly zero) when the expansion in government expenditure is financed with lump sum taxation; they even turn negative when a certain fraction is financed with distortionary taxation. To understand the reason for such bad performance of an expansionary fiscal policy, we examine the impulse responses of a set of selected variables to the same temporary government expenditure shock. Figure 2 shows that, in response to a temporary increase in government expenditure, employment and output drop, the more so the higher the ϕ. As explained for the RBC model with search and matching frictions, an increase in current vacancy posting requires an increase in the continuation value of a filled vacancy. Such an increase however cannot take place as it would require an increase in current consumption, which, on the contrary falls due to the

[6] When considering a Walrasian labor market N denotes hours worked and not employed workers (intensive instead of extensive margin).

crowding out effect. The fall in current vacancies brings about a fall in job creation and employment. The fall in employment triggers a fall in output, which more than compensates the increase in aggregate demand. Differently from the RBC version, since prices will not adjust completely, there will be a temporary reduction in price markups that will alleviate the crowding out effect on consumption. This is why, compared to the RBC case, multipliers are in general bigger. Our model highlights a novel dimension in the analysis of fiscal multipliers, as in a model with a non-Walrasian labor market changes in output are determined also by changes in labor demand, alongside with changes in aggregate demand. The positive effect on aggregate demand due to price rigidity is barely enough to compensate for the labor demand effect under lump sum taxation (multipliers are nearly zero). As soon as distortionary taxation is introduced, the multipliers turn negative.

Figure 3 shows the fiscal multipliers in the standard New Keynesian model. Once again the exact numbers are also summarized in Tables 1 and 2 for both, short run and long run multipliers. From the comparison with the previous model several considerations emerge. First, multipliers in this case are all positive and larger than in the model with a non-Walrasian labor market. Figure 4 shows impulse responses of selected variables to the usual temporary shock to government spending. In this case, and contrary to the previous case, we observe an increase in employment and in output. Interestingly multipliers are positive even when financing occurs with distortionary taxation. This is in contrast with the results that Uhlig (21) finds for the RBC model with capital, in which an increase in government spending financed through distortionary taxes leads to negative long-run multipliers.

To deepen the comparison between the model with and without Walrasian labor market, Figure (5) plots a set of selected variables for both models in the same panels. Calibration of the ϕ parameter is equal to zero, thus we consider lump sum taxation. Interestingly, we see that in the model with non-Walrasian labor markets there is nearly no increase in employment. This is due to the increase in the wage bill. As a consequence the crowding out effect on private consumption is larger in the model with non-Walrasian labor markets: the

wealth allocated to workers is smaller in this case, hence their consumption falls by more.

One clear conclusion that emerges from those first experiments is that the evaluation of fiscal stimuli might be too optimistic when the model employed neglects frictions in the labor market. This is in sharp contrast to the common wisdom which fosters the idea that large fiscal packages are needed exactly when unemployment is high.

4.2 Alternative Forms of Fiscal Stimuli

In practice fiscal stimuli have taken various forms, which go beyond the mere increase of aggregate demand. Our model allows in particular to highlight the role of subsidies to the labor market, which is one very popular forms of fiscal stimuli. Ex-ante we can consider two possibilities: increases in the unemployment benefit and subsidies to the cost of posting vacancies.

We do not devote much space to the first case, an increase in unemployment benefit, as we expect this measure to deliver always negative multipliers in our model. An increase in unemployment benefit raises the equilibrium wage as shown in equation (20). An increase in wages reduces vacancy posting and employment. This induces large falls in output and strongly negative fiscal multipliers. In practice, during the last crisis, several governments have undertaken measures to subsidize and increase the duration of unemployment benefits. This induces us to think that such policies might show some merits. However, for an increase in unemployment benefit to be beneficial, it would require to augment the model with frictions along the labor supply schedule. If changes in unemployment benefits could boosts labor market participation, increases in the length and the size of unemployment subsidies might help to boost employment.

The alternative form of fiscal stimuli which can be usefully analyzed in our model consists in an increase in the subsidy to the cost of posting vacancies. Figure 6 shows fiscal multipliers for a temporary increase in the subsidy to the cost of posting vacancies for different values of ϕ. Again Tables 1 and 2 report exact numbers for both, short run and long run multipliers. A temporary 1% increase in the subsidy to the cost of posting a vacancy generates a strong

positive fiscal multiplier, both, in the short and in the long run. This is so independently of the financing strategy adopted, lump sum versus distortionary labor tax. The multipliers are actually larger under the benchmark scenario of partial financing with distortionary taxation ($\phi = 0.275$) and deficit. Reducing the cost of posting a vacancy increases the number of vacancies, which in turn raises job creation and reduces unemployment. This has a direct positive impact on employment and consumption, as shown by the impulse response functions shown in Figure 7. The cost of posting vacancies introduces a gap between the model with Walrasian and non-Walrasian labor markets, hence reducing this gap brings the model closer to the standard New Keynesian model which features larger multipliers. In addition our model features inefficient unemployment fluctuations as our parametrization brings the model away from the Hosios (12) condition. In these circumstances a fall in the cost of posting vacancy can reduce the wedge in the labor demand schedule, therefore bringing employment and output closer to the pareto efficient level.

We conclude that when frictions operate mainly along the labor demand side and when inefficient fluctuations in unemployment occur, policy makers should direct their fiscal stimuli toward measures that directly increase the number of available jobs.

4.3 Robustness Checks

Recession scenario. Governments have recently passed large fiscal packages to fight the recessionary impact of the current financial crisis. The question arises whether the effectiveness of fiscal stimuli changes when the economy starts from a recession scenario. We analyze this case and implement a recession scenario assuming a one percent temporary drop in total factor productivity.[7] Figure 8 and Figure 9 show the responses of GDP and employment in the model with search and matching frictions for the case in which the recession is followed by a policy intervention (solid lines) and for the case in which no policy intervention takes place (dashed lines). We consider policy interventions in terms of a temporary one percent increase in government spending and in terms of an increase in the cost of posting vacancies

[7] The degree of autocorrelation of the TFP process is set to 0.95.

of 2 percentage points. We restrict the analysis by considering two cases: lump sum taxation, which is depicted in the first two panels, and distortionary taxation with $\phi = 0.275$, which is depicted in the bottom panels.

The analysis confirms our previous findings. A pure demand stimulus has negligible effects when financed by raising lump sum taxes. Moreover, when financed partly with distortionary taxes, an expansion in government spending even deepens the economic downturn. A hiring subsidy, on the other hand, dampens the recession triggered by the drop in productivity. This policy intervention is particularly powerful in fighting the drop in employment. Remarkably, the costs incurred by a 2 percentage point increase in the hiring subsidy accounts for only 0.04 percent of GPD, whereas a one percent increase in government spending costs approximately 0.15 percent of GDP.

Interest rate peg. Over the last year, countries like the U.S. have adopted a policy mix in which the monetary authority has kept the interest rate fixed at low levels, while the fiscal authority had passed large fiscal packages. There has been a widespread consensus that, when the interest rate is close to the zero lower bound, fiscal policy might have a stronger leverage than monetary policy. To verify whether those statements are correct we repeat our experiments in combination with a temporary interest rate peg (the monetary authority keeps the nominal interest rate constant for one year).

As shown in Table 1 and 2, in this case a demand stimulus induces large positive multipliers both, in the standard New Keynesian model and in the model with search and matching frictions. Additionally, in the model with search and matching frictions, an interest rate peg tends to dampen the crowding out effects generated in the long run by an increase in aggregate demand financed through distortionary taxation. These results echo the ones reported in Christiano, Eichenbaum and Rebelo (4).

It is worth noticing, however, that, even when an interest rate peg is considered, it remains true that search and matching frictions dampen the positive effects of expansionary fiscal policies.

Next, we analyze the effects of subsidizing the cost of posting vacancies in presence of an interest rate peg. Again, results are reported in Tables 1 and 2. Surprisingly, this type of policy mix is very unsuccessful as multipliers are nearly zero and they even turn negative. A reduction in the cost of posting vacancies allows firms to increase the number of vacancies only when accompanied by a fall in the nominal interest rate. When the interest rate stays constant, the discounted future values of new vacancies as well as firms' incentives to post new vacancies tend to decrease.

Price and Wage Rigidity. Furthermore, we re-examine fiscal multipliers for different degrees of price rigidity. We set the cost of adjusting prices, ψ, to 9.9 and 58 to generate a slope of the log-linear Phillips curve consistent with an average price duration of two and four quarters, respectively. When considering the demand stimulus, higher price rigidity increases the short and long run fiscal multipliers (both for the aggregate demand and for the GDP). This is so both, for the case of lump sum taxation and for distortionary taxation. This is in line with the results found by the previous literature examining New Keynesian models with Walrasian labor markets. When considering an increase in the hiring subsidy, some degree of price rigidity seems to make the fiscal stimulus more powerful, although the relation does not seem to be always monotonic. Importantly, results show that, independently of the degree of price rigidity, matching frictions dampen fiscal multipliers when demand stimuli are considered.

This finding is also true when considering real wage rigidity or when varying the worker's bargaining power. We consider those two additional cases as they are the hypothesis considered in the literature to solve the so-called Shimer puzzle. First, we assume wages to be set according to the partial adjustment equation $w_t = \gamma w_{t-1} + (1-\gamma) w_t^*$, where w_t^* is described by the baseline wage equation (20) and the degree of real wage rigidity, γ, is calibrated to 0.9. An increase in aggregate demand produces an increase in wages which induces a fall in vacancy posting and thus employment. Under real wage rigidity, the upward pressure on wages is dampened which gives rise to larger multipliers. However, our results show that the

effects of a demand stimulus are still considerably smaller when the model with search frictions is compared to a model with a Walrasian labor market. Finally, we vary the workers' bargaining power, ς. Even in this case previous results are largely confirmed.

5 Conclusions

We provide some fiscal calculus for a New Keynesian model with search and matching frictions. We do so by considering fiscal packages in the form of demand stimuli and in the form of subsidies to the cost of posting vacancies. We also analyze the effects of alternative forms of financing in terms of lump sum versus distortionary taxation. By comparing the results obtained in our model with the ones obtained in a standard New Keynesian model, we find that frictions in the labor market tend to dampen fiscal multipliers when demand stimuli are considered. This seems to contrast the common wisdom which sees fiscal stimuli particularly helpful exactly in situations of high unemployment. On the other side, policies targeted more specifically toward the labor market, particularly those aimed at reducing labor wedges, such as cost of hiring, are particularly effective in boosting employment and output.

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Table 1: GDP multiplier

	$\phi = 0$		$\phi = 0.275$	
	SR multiplier	LR Multiplier	SR Multiplier	LR Multiplier
Demand stimulus				
Baseline model	0.0327	0.0327	-0.1958	-0.6665
Interest rate peg	1.4908	0.2562	0.9486	-0.3784
Flexible prices ($\psi = 0$)	-0.0173	-0.0324	-0.0965	-0.7281
Price rigidity $\psi = 9.9010$	-0.0072	-0.0110	-0.1159	-0.7106
Price rigidity $\psi = 58.2524$	0.1207	0.0922	-0.2739	-0.5554
Real wage rigidity ($\gamma = 0.9$)	0.1412	0.0287	-0.1478	-0.6182
Bargaining power $\varsigma = 0.7$	0.0394	0.0437	-0.1717	-0.6774
Bargaining power $\varsigma = 0.3$	0.0108	0.0078	-0.2748	-0.6421
Walrasian labor market	0.5501	0.5499	0.3687	0.1251
Walrasian / Interest rate peg	0.9963	0.6432	0.7889	0.2519
Walrasian / $\psi = 0$	0.5407	0.5407	0.4690	0.1218
Walrasian / $\psi = 9.9010$	0.5441	0.5440	0.4233	0.1173
Walrasian / $\psi = 58.2524$	0.5579	0.5576	0.2651	0.2638
Increase in hiring subsidies				
Baseline model	4.3341	4.5421	5.2528	6.0592
Interest rate peg	-1.5721	3.1046	-0.3097	4.0887
Flexible prices ($\psi = 0$)	2.4371	4.5152	2.6880	6.0379
Price rigidity $\psi = 9.9010$	3.0478	4.5827	3.5751	6.1896
Price rigidity $\psi = 58.2524$	5.1046	4.2244	5.9689	5.3600
Real wage rigidity ($\gamma = 0.9$)	5.0711	4.3669	5.6705	5.7129
Bargaining power $\varsigma = 0.7$	8.2819	9.5737	9.9397	13.5126
Bargaining power $\varsigma = 0.3$	3.0177	2.3939	3.8542	2.8683

Table 2: Aggregate demand multiplier

	$\phi = 0$		$\phi = 0.275$	
	SR multiplier	LR Multiplier	SR Multiplier	LR Multiplier
Demand stimulus				
Baseline model	0.0125	0.0262	-0.0968	-0.5739
Interest rate peg	0.6369	0.2073	0.4342	-0.3296
Flexible prices ($\psi = 0$)	-0.0085	-0.0278	-0.0473	-0.6234
Price rigidity $\psi = 9.9010$	-0.0047	-0.0101	-0.0570	-0.6094
Price rigidity $\psi = 58.2524$	0.0524	0.0759	-0.1375	-0.4821
Real wage rigidity ($\gamma = 0.9$)	0.0662	0.0231	-0.0741	-0.5318
Bargaining power $\varsigma = 0.7$	0.0273	0.0392	-0.1345	-0.6384
Bargaining power $\varsigma = 0.3$	-0.0053	0.0034	0.0396	-0.4373
Walrasian labor market	0.5500	0.5499	0.3687	0.1245
Walrasian / Interest rate peg	0.9858	0.6416	0.7852	0.2508
Walrasian / $\psi = 0$	0.5407	0.5407	0.4690	0.1218
Walrasian / $\psi = 9.9010$	0.5441	0.5439	0.4233	0.1172
Walrasian / $\psi = 58.2524$	0.5578	0.5576	0.2627	0.2624
Increase in hiring subsidies				
Baseline model	2.1121	3.8749	2.5570	5.1683
Interest rate peg	-0.9784	2.6204	-0.2292	3.4805
Flexible prices ($\theta = 0$)	1.1905	3.8623	1.3127	5.1645
Price rigidity $\psi = 9.9010$	1.4859	3.9168	1.7414	5.2898
Price rigidity $\psi = 58.2524$	2.1839	3.5954	2.9013	4.5606
Real wage rigidity ($\gamma = 0.9$)	2.4690	3.7258	2.7593	4.8743
Bargaining power $\varsigma = 0.7$	6.4283	8.9492	7.7147	12.6305
Bargaining power $\varsigma = 0.3$	-0.5332	1.5962	-0.7057	1.9005

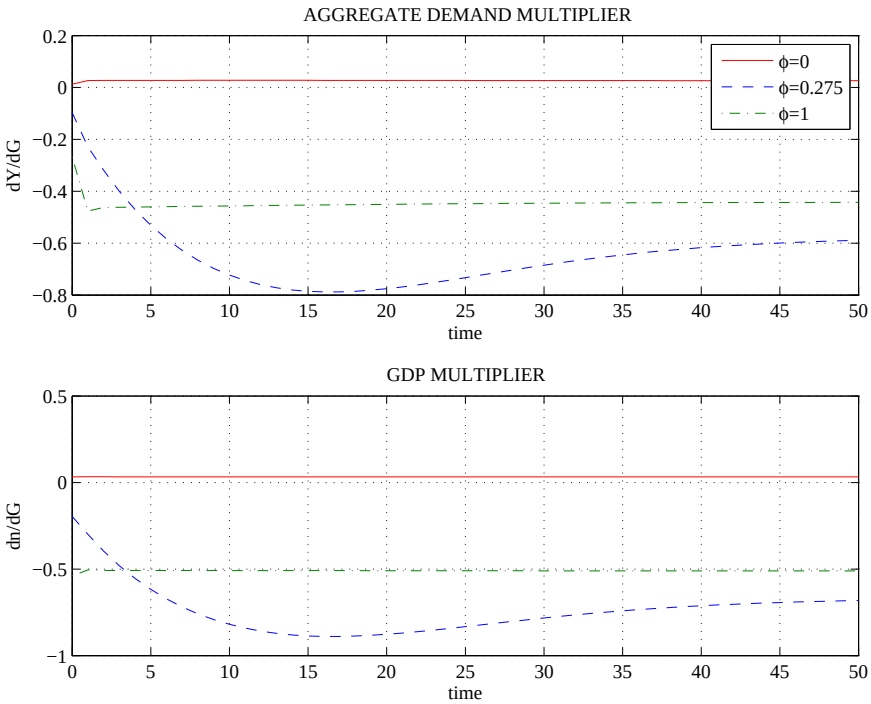

Figure 1: Government spending multipliers in a model with search frictions

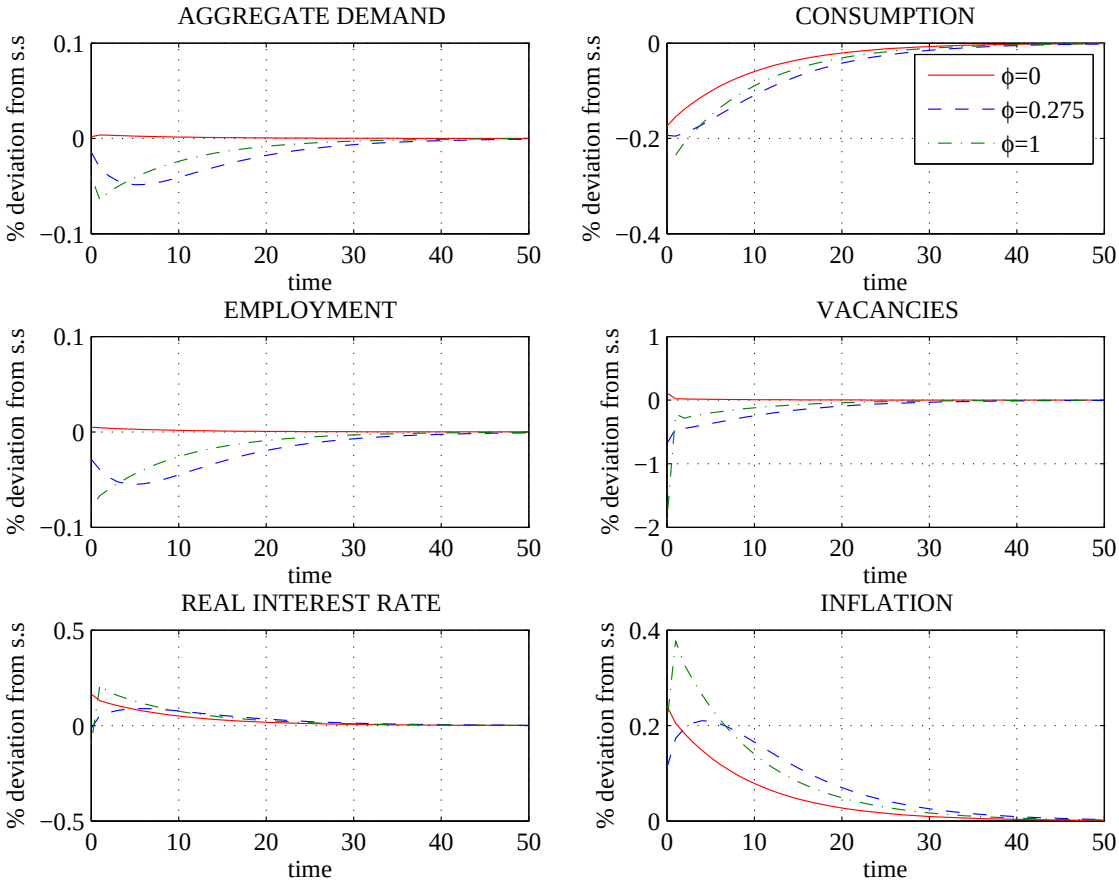

Figure 2: Impulse responses to a temporary increase in government spending in a model with search frictions

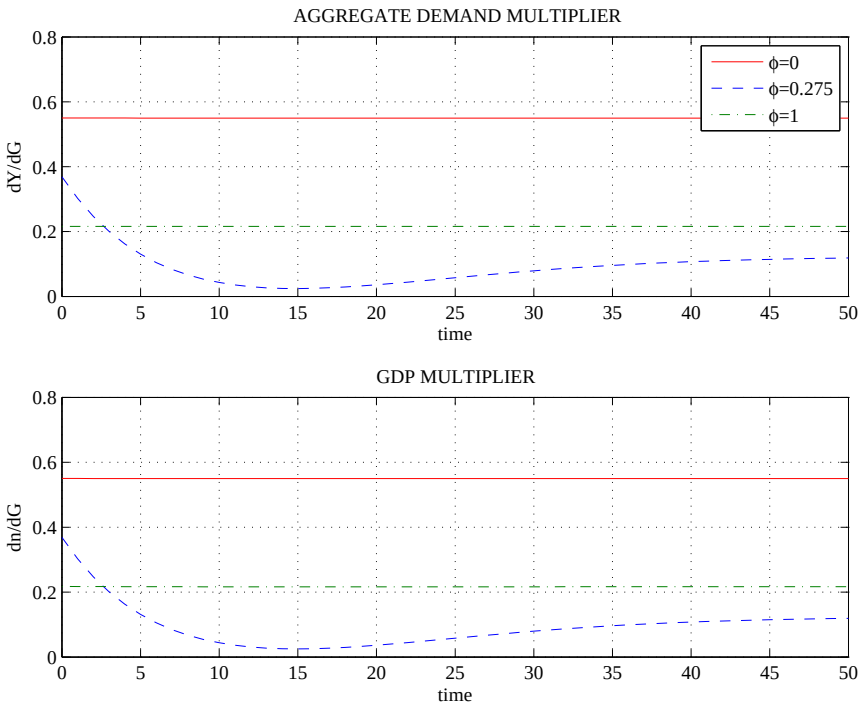

Figure 3: Government spending multipliers in a model with a Walrasian labor market

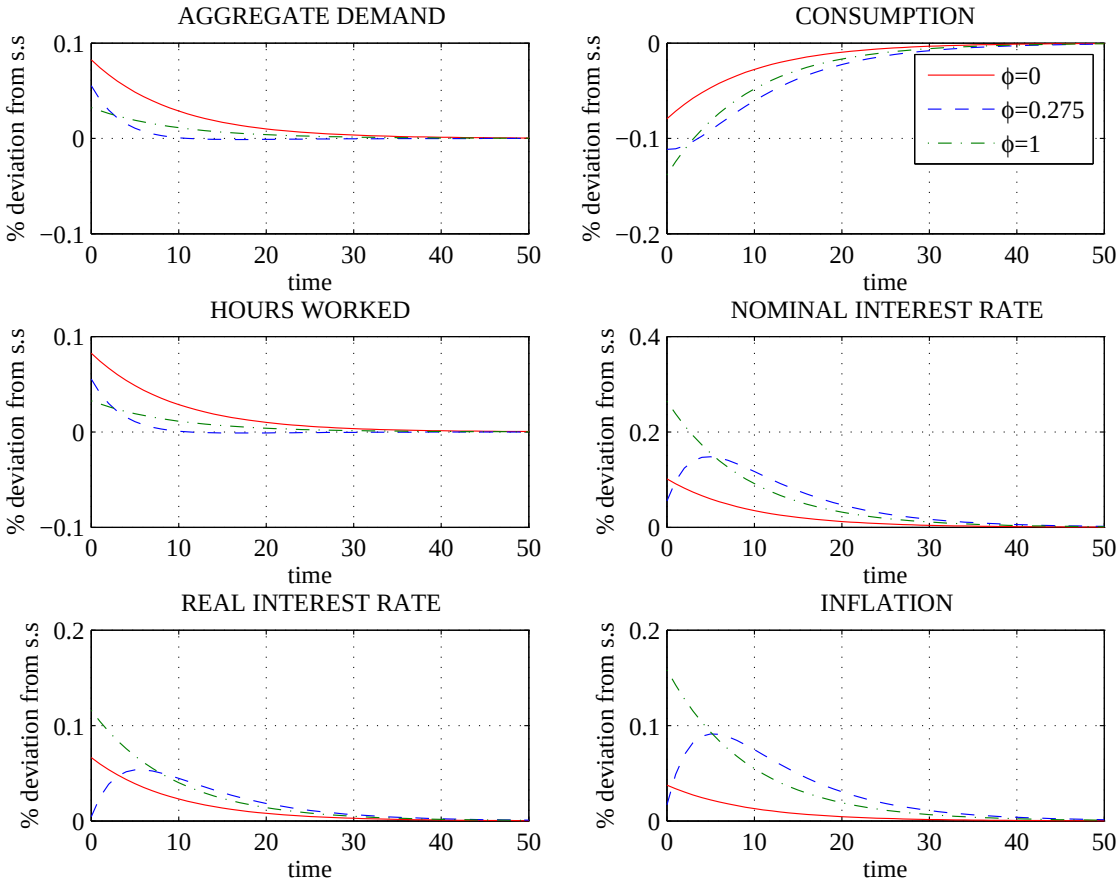

Figure 4: Impulse responses to a temporary increase in government spending in a model with a Walrasian labor market

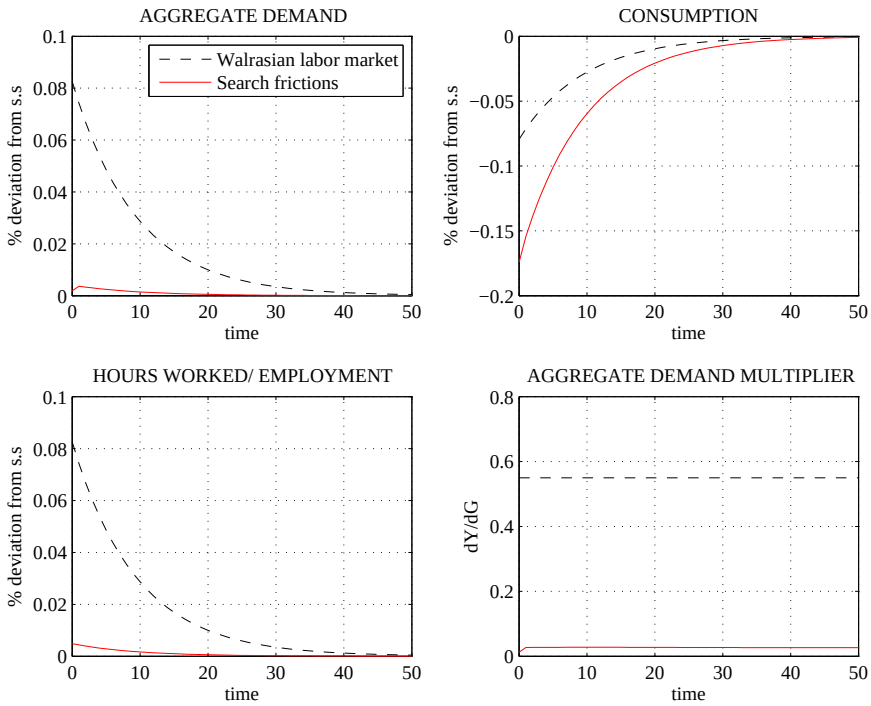

Figure 5: Impulse responses to a temporary increase in government spending with lump sum taxation

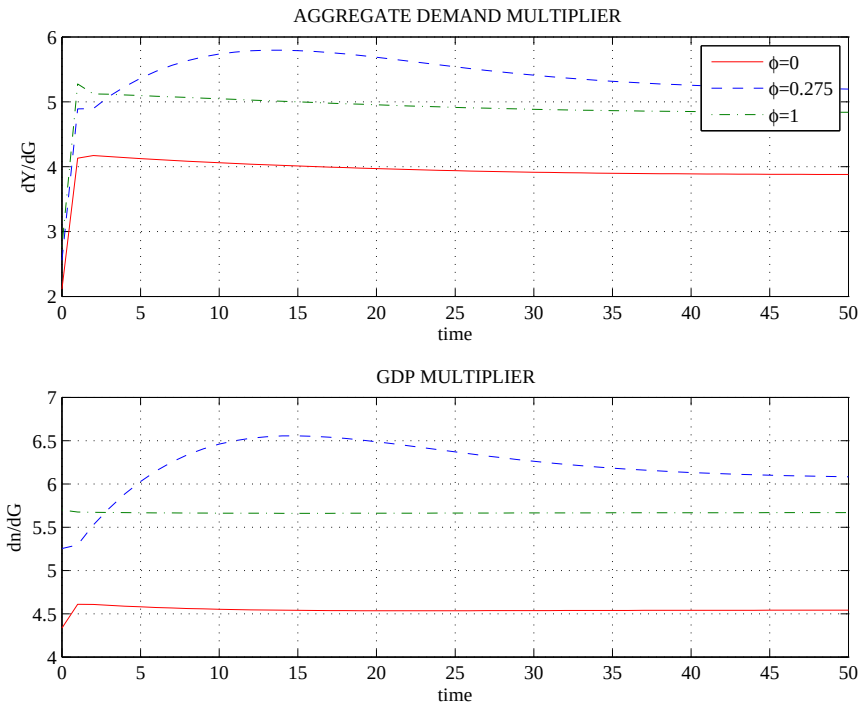

Figure 6: Fiscal multipliers for a temporary increase in the subsidy to the cost of posting vacancies

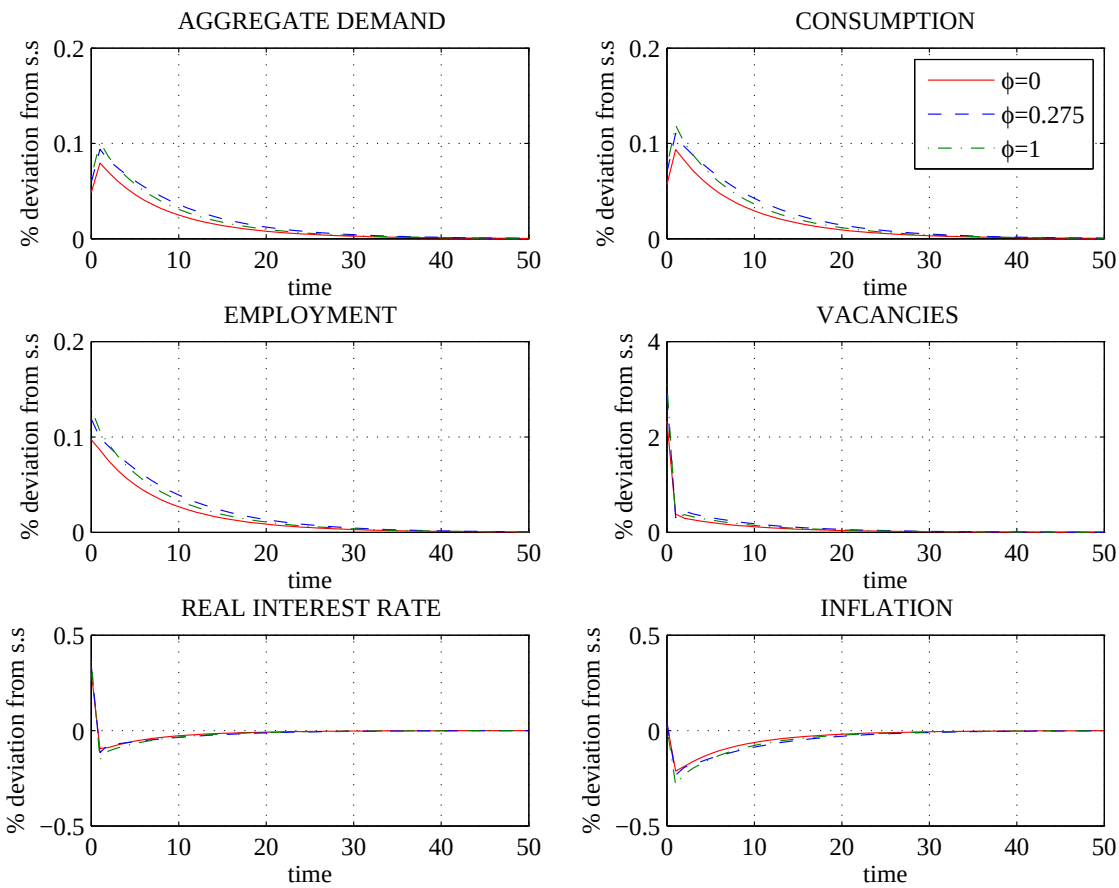

Figure 7: Impulse responses to a 1% temporary increase in the subsidy to the cost of posting vacancies

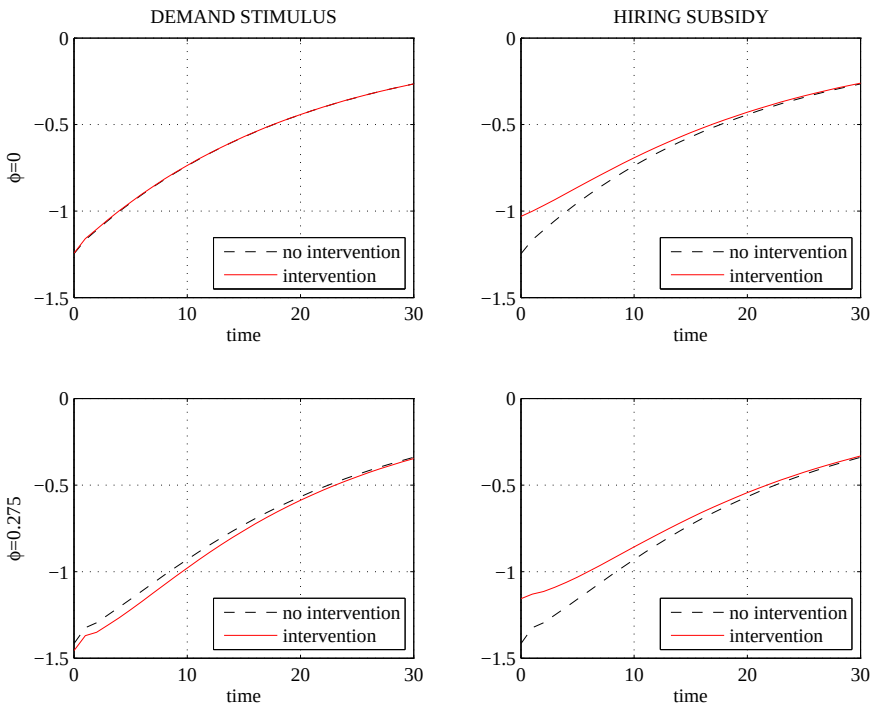

Figure 8: Response of GDP under a temporary increase in government spending (left column) and under a temporary subsidy to the cost of posting vacancies (right column) starting from a recession scenario for $\phi = 0$ (first row) and $\phi = 0.275$ (second row)

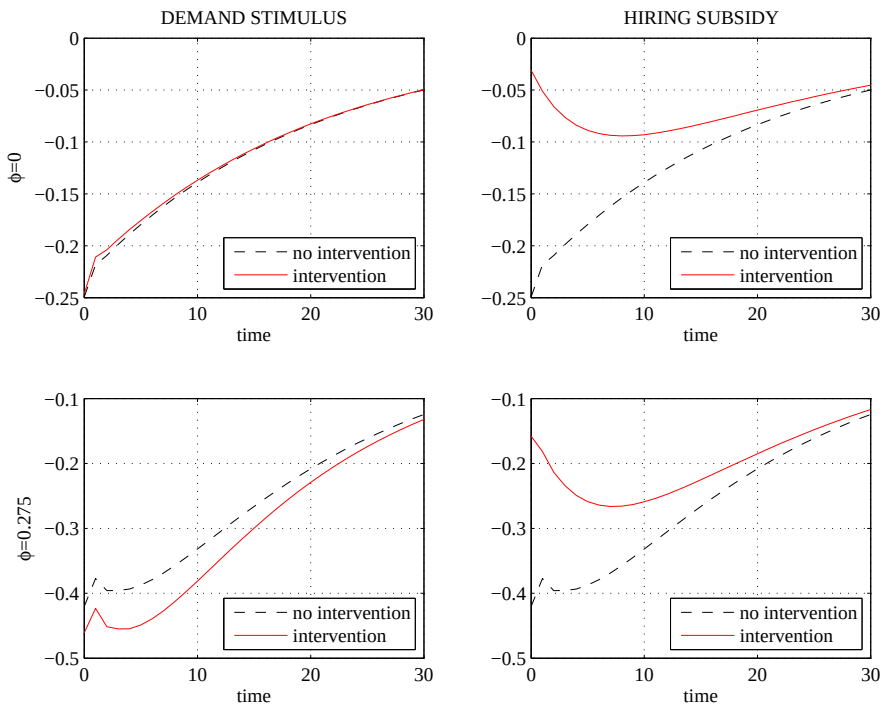

Figure 9: Response of employment under a temporary increase in government spending (left column) and under a temporary subsidy to the cost of posting vacancies (right column) starting from a recession scenario for $\phi = 0$ (first row) and $\phi = 0.275$ (second row)